2002 Human-Technology Integration Colloquium Series
Air Force Research Laboratory
Human Effectiveness Directorate

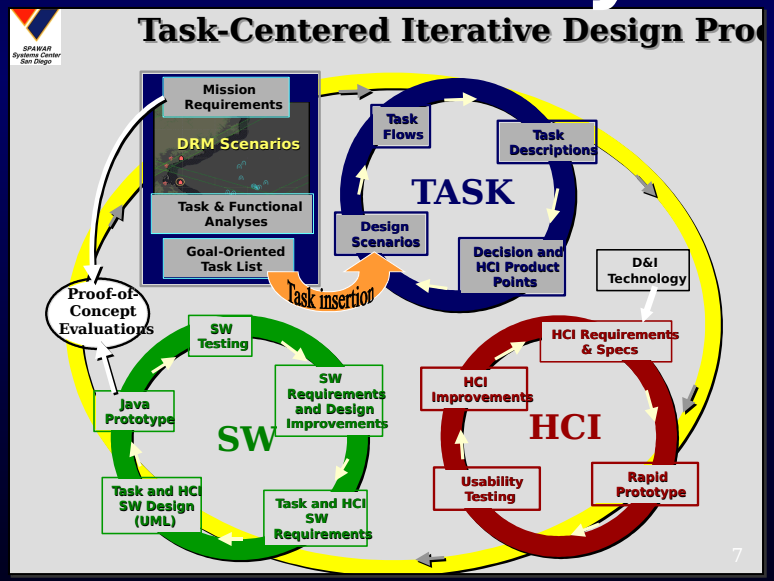
The Iterative HCI Design Process (Part 1 of 3 Design Methods and Products)

Dr. Glenn Osga
Space & Naval Warfare Center San Diego

26 June 2002 2:00 PM

Overview

- Design Process
- Multimodal Watchstation
- Analysis Products



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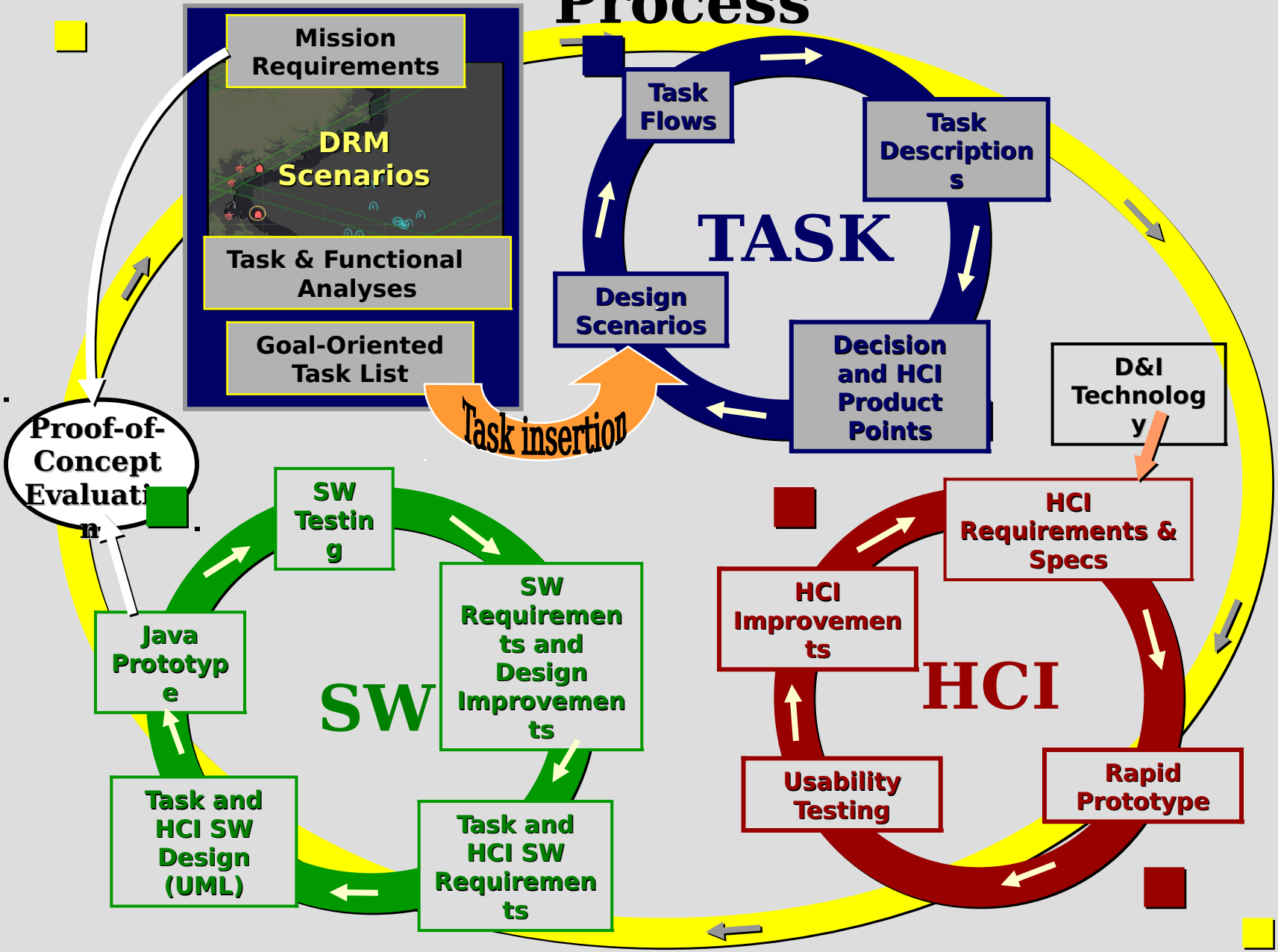
Why Iterative Design?

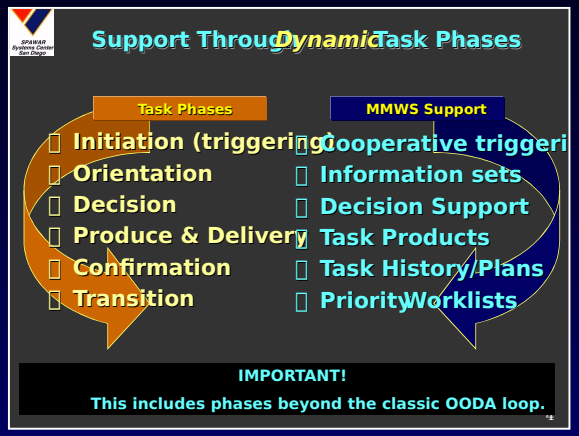
- Large complex C4I systems - requirements evolve & change.
- Planning and building software for iteration keeps capability more “current”.
- With smaller budgets - not all capability can be built at once - staged improvements.
- Incorporating usability and other performance tests results into design improves end product.
- Achieve performance, safety, training threshold requirements and then go beyond without pause.
- Strive for improved R&D to product transition.

Task-Centered Iterative Design Process



Design Process Overview

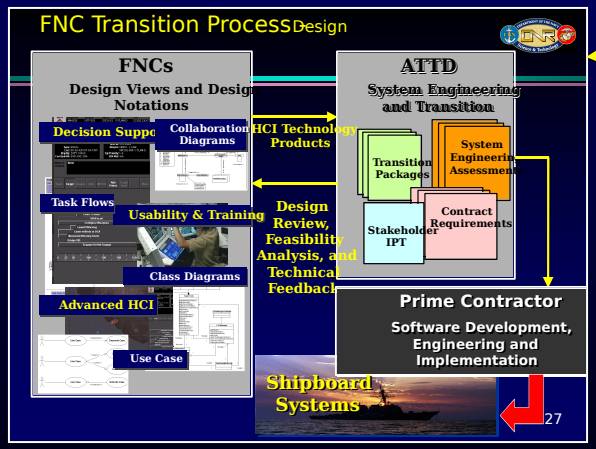
Task Analysis

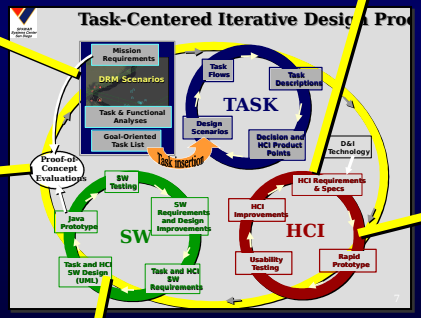


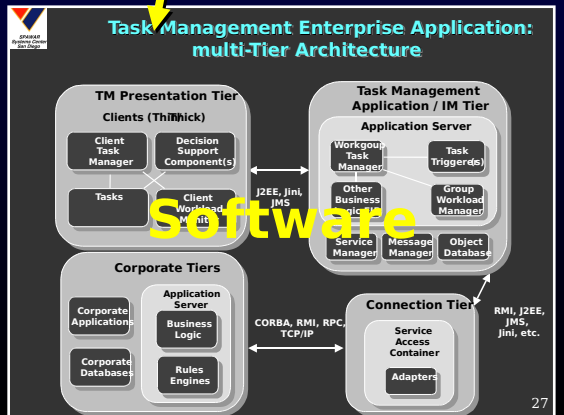
HCI Prototyping

Testing

Transition







Human Performance: Visual, Cognitive, Auditory, Psychomotor

Transition Products & Process

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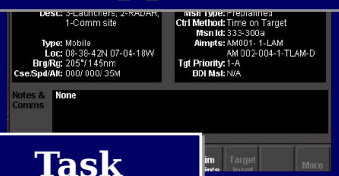
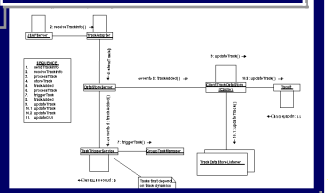
Models, Tools, Design

Decision Support

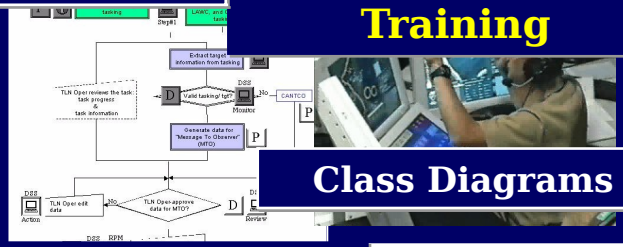
Collaboration Diagrams





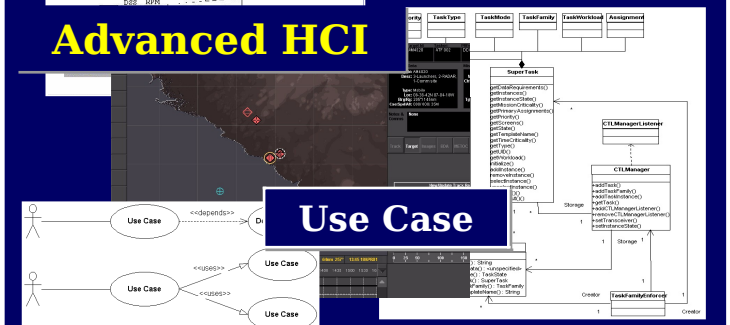
Task Flows

Usability & Training

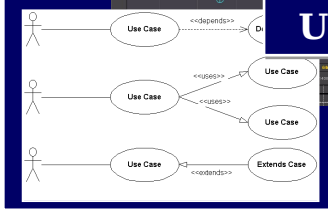


Class Diagrams

Advanced HCI



Use Case



HCI Technology Products

Design Review, Feasibility Analysis, and Technical Feedback

System IPTs

System Engineering and Transi

Transition Packages

System Engineering Assessme

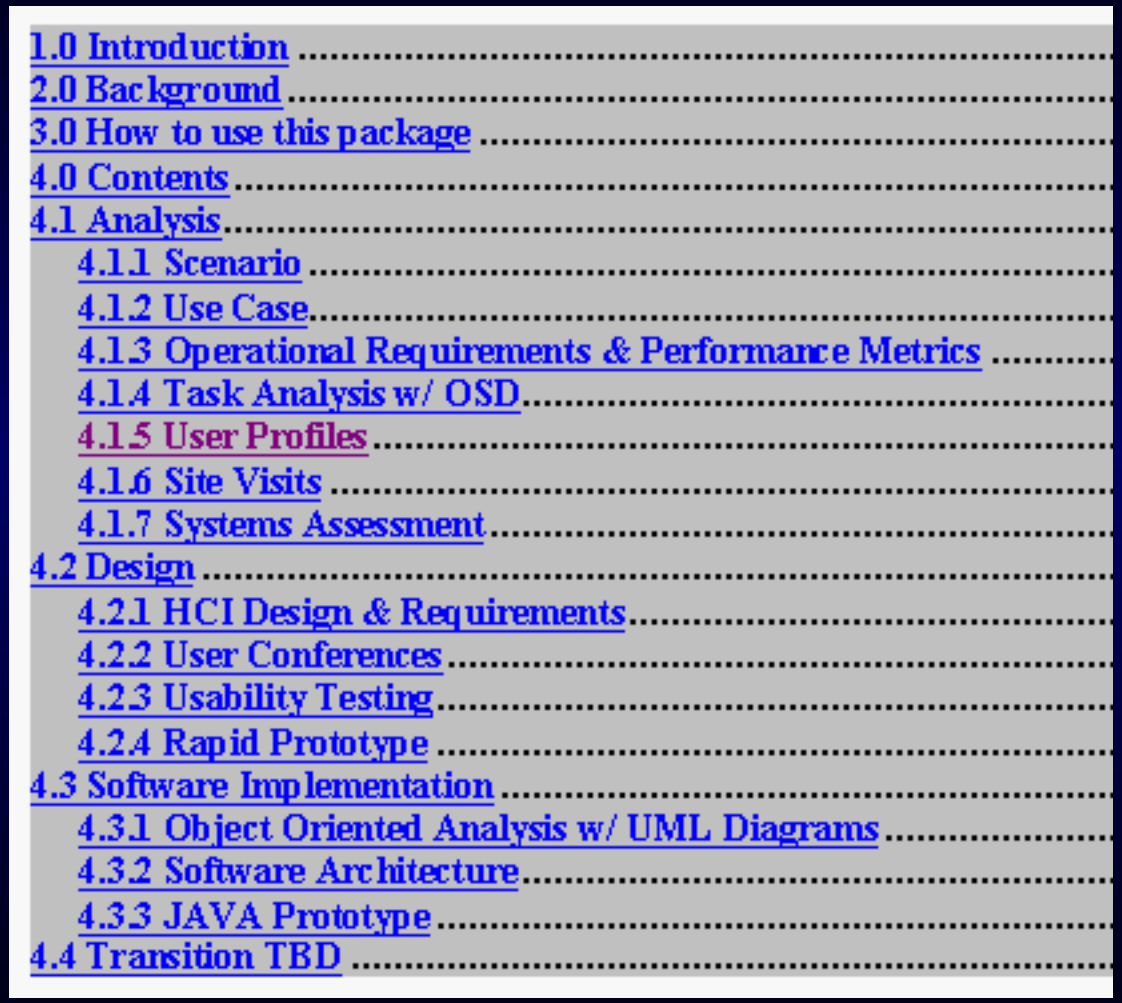
Stakeholder IPT

Contract Requirements

Prime Contractor

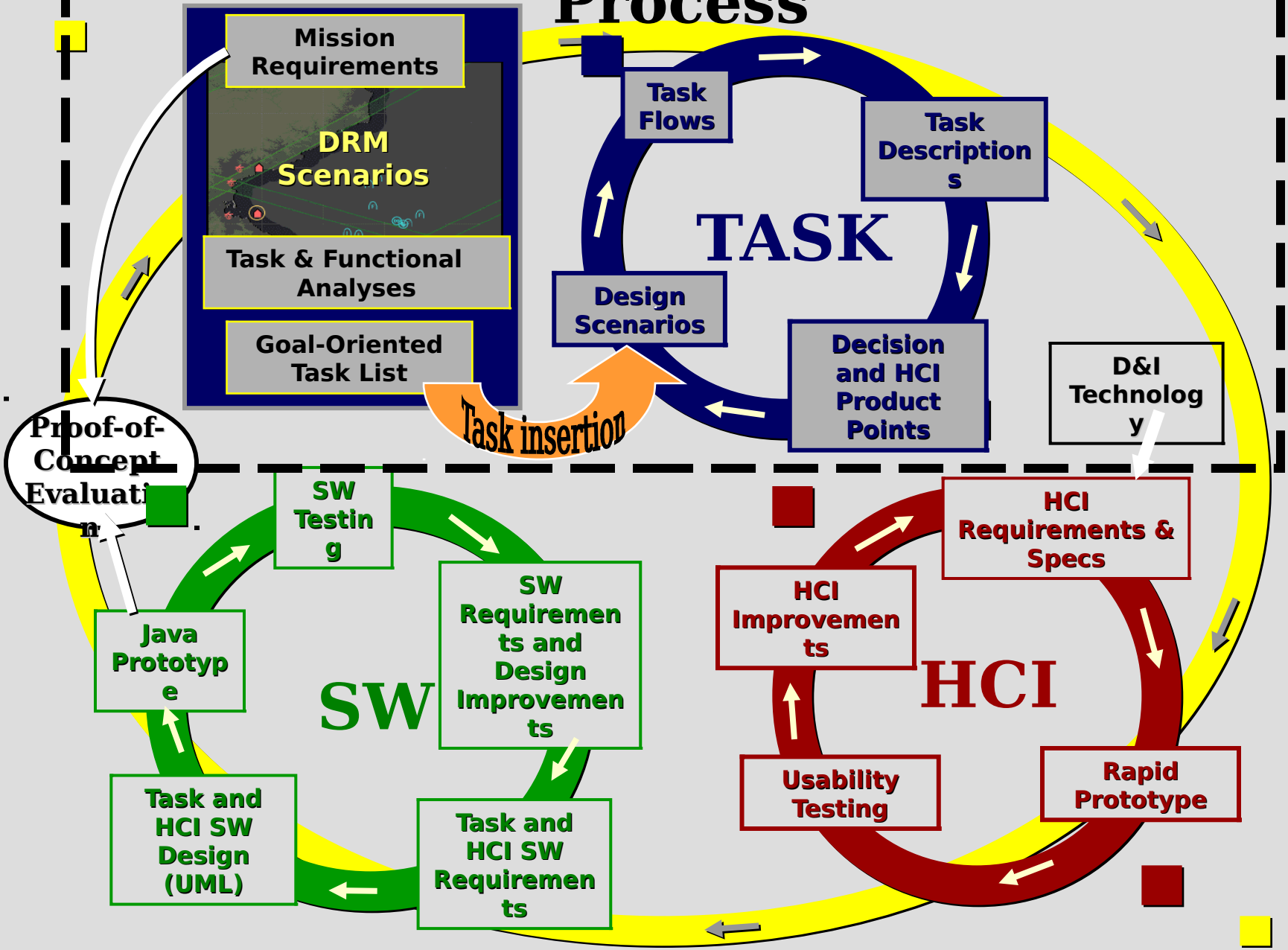
Software Development, Engineering and Implementation

Design Information View



Shared by HFE & software designers for a common design view

Task-Centered Iterative Design Process



Task-Centered Design Approach

Task Types:

- Tactical/Mission
- Work Management
- Communication
- Computer

Task Support:

- Decision Aids
- Work Management Aids
- Communication Efficiency Aids
- Adv Interface Features

All these tasks make demands on warfighter Cognitive - Visual - Psychomotor sub-systems

Task-Centered Design Approach

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Task Phases:

- Initiation (triggering)
- Orientation
- Decision
- Produce & Delivery
- Confirmation
- Transition

Adv Interface Support

- Cooperative triggering
- Information sets
- Decision Support
- Task Products
- Task History/Plans
- Priority Worklists

Supervisory Control HCI

Mission Process Tasks - Gun CFF

Today/Future

TSC+LAC

GLO+ECO =LAWC

EP+LC= "LAO"

CFF Receipt

Target Assignment

Comply/Deviate/ Waiver/CANTCO

Targeting Solution

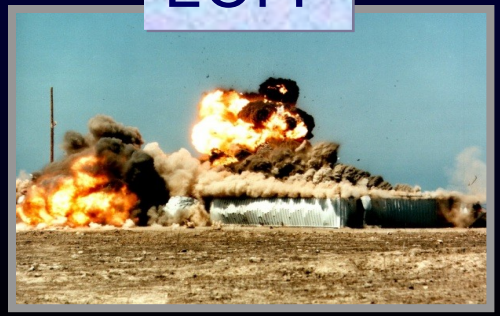
Deconfliction

Recommend Execute

Post-Fire Messages

Adjust Fire

EOM



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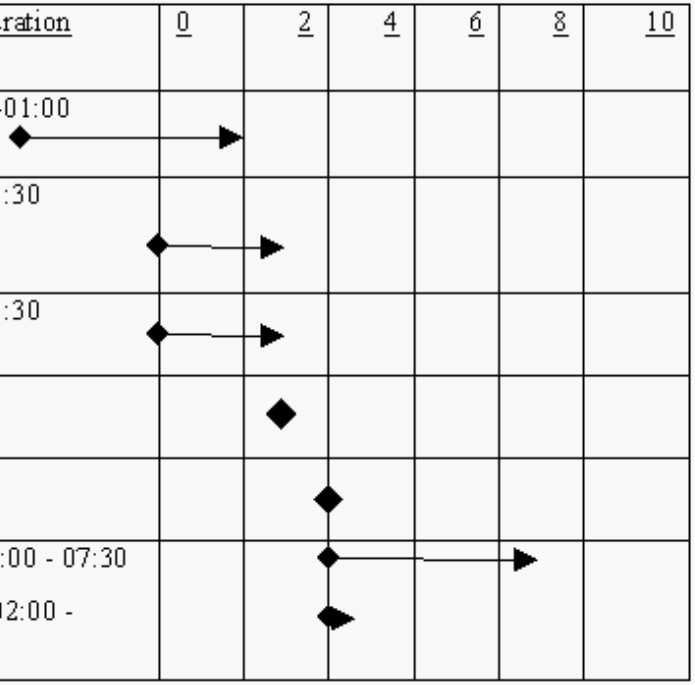
Design Reference Mission(s)

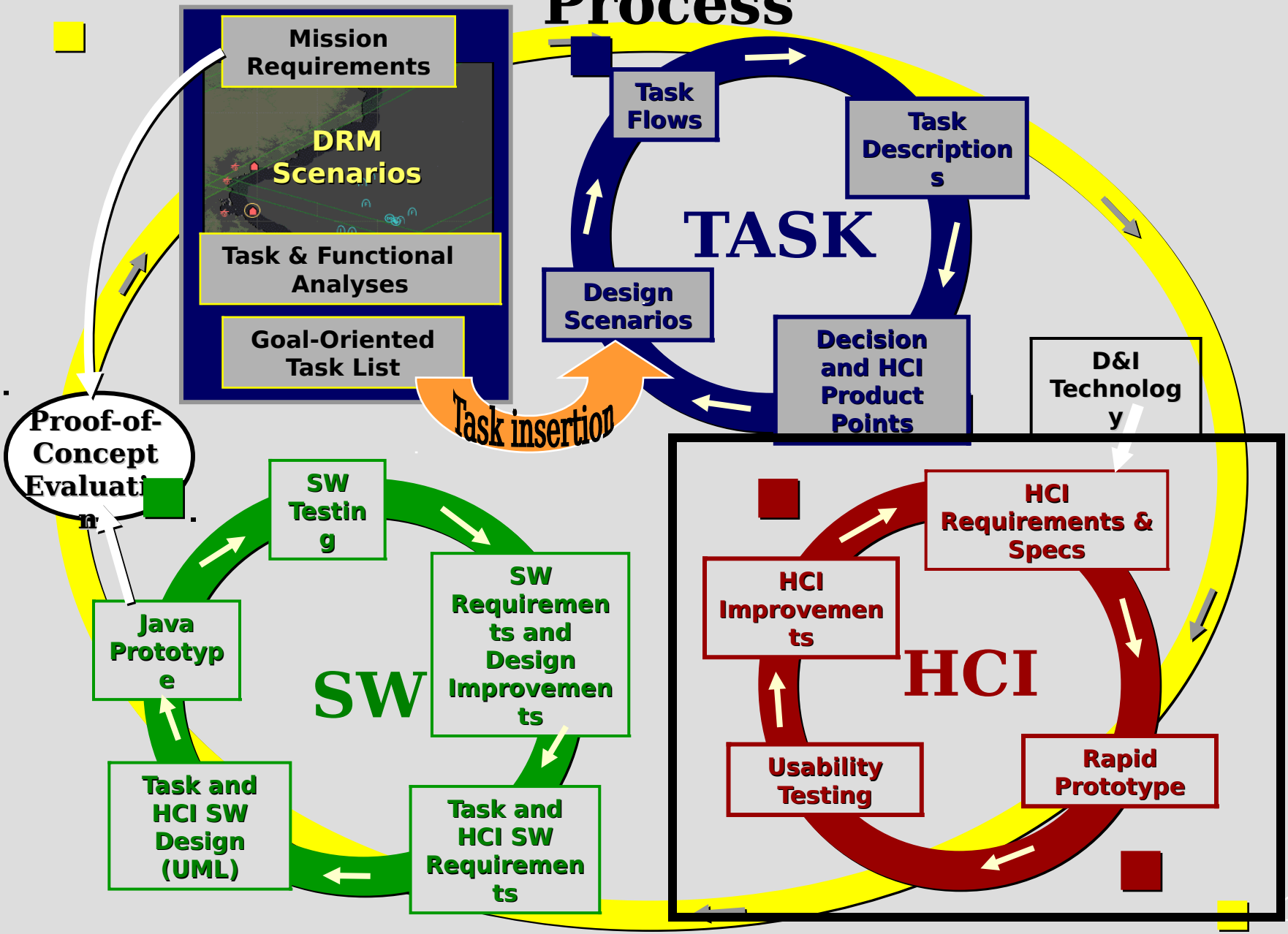
Pre-scenario events

Yesterday DDG 82 conducted a strike mission against the Nimba Airfield. BDA has not yet been received. Forward Command Element (FCE) arrived at the US Embassy during the hours of darkness; established communications with the SACC. DDG 82 is in the operations area and is prepared to conduct fire support operations.

Seq	Event	Time Duration (min)[2]
1	The 1st Infantry Platoon, with Naval Gunfire Spot Team, helo lifts to co-locate with the Forward Command Element (3 CH-46/ 1 AH-1Z).	(-)10:00-01:00
2a	Receive, process, store ASCM (Helo Airlanes for Evacuation (ARG<>Embassy & ARG<>Sierra Leone).	00:00-01:30
2b	Receive, process, store FSCM (No Fire Areas).	00:00-01:30
3	Receive/Display BDA for Nimba Airfield	01:30
4	Receive retasking for Nimba Airfield from FCE (Tgt # 9601)	02:00
5	Execute NSFS fire plan for Nimba Airfield. (2 targets/3 aimpoints; 2-ERGM, 1-LAM)	LAM 02:00 - 07:30 ERGM 02:00 - 02:45



Task-Centered Iterative Design Process



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Multi-Modal Watchstation

Key Features

- Work Visualization
- Mission Plans & Goals
- Draft Task “Products” with automation support
- Consistent visual components
- Task Management
- Multi-Tasking Support

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Task Information Sets Assigned to Each Displa

Tactical Situation Map & Controls

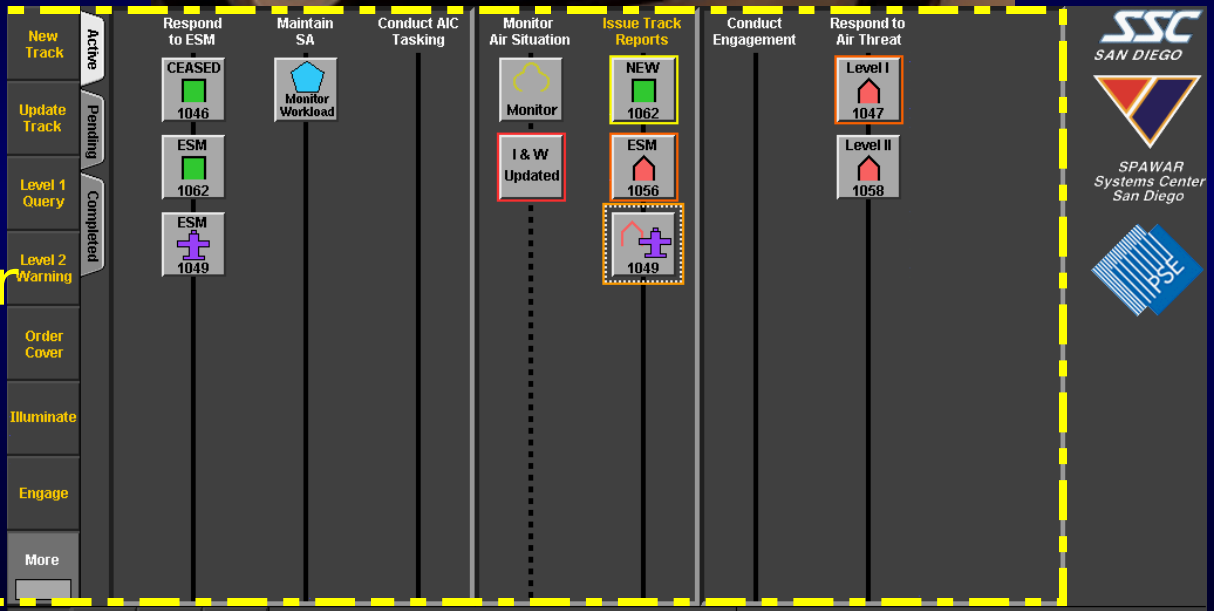
Amplifying Track and Response Planning Information

Priority Tracks Awaiting Task Completion

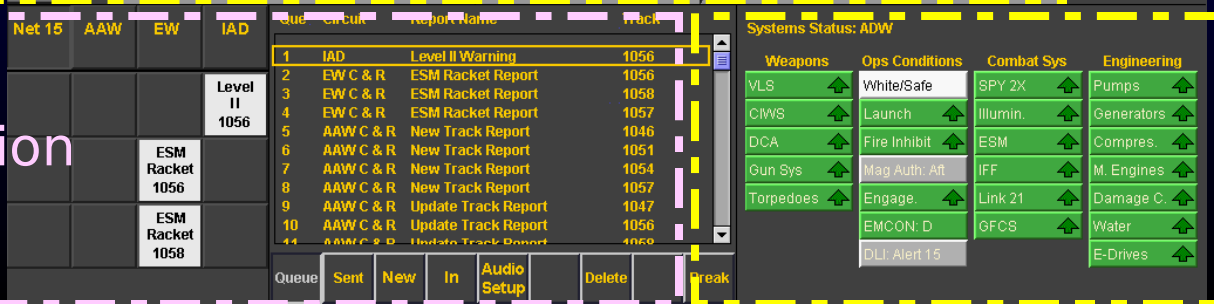
Draft Task Product Summary

Task Manager & Status Display

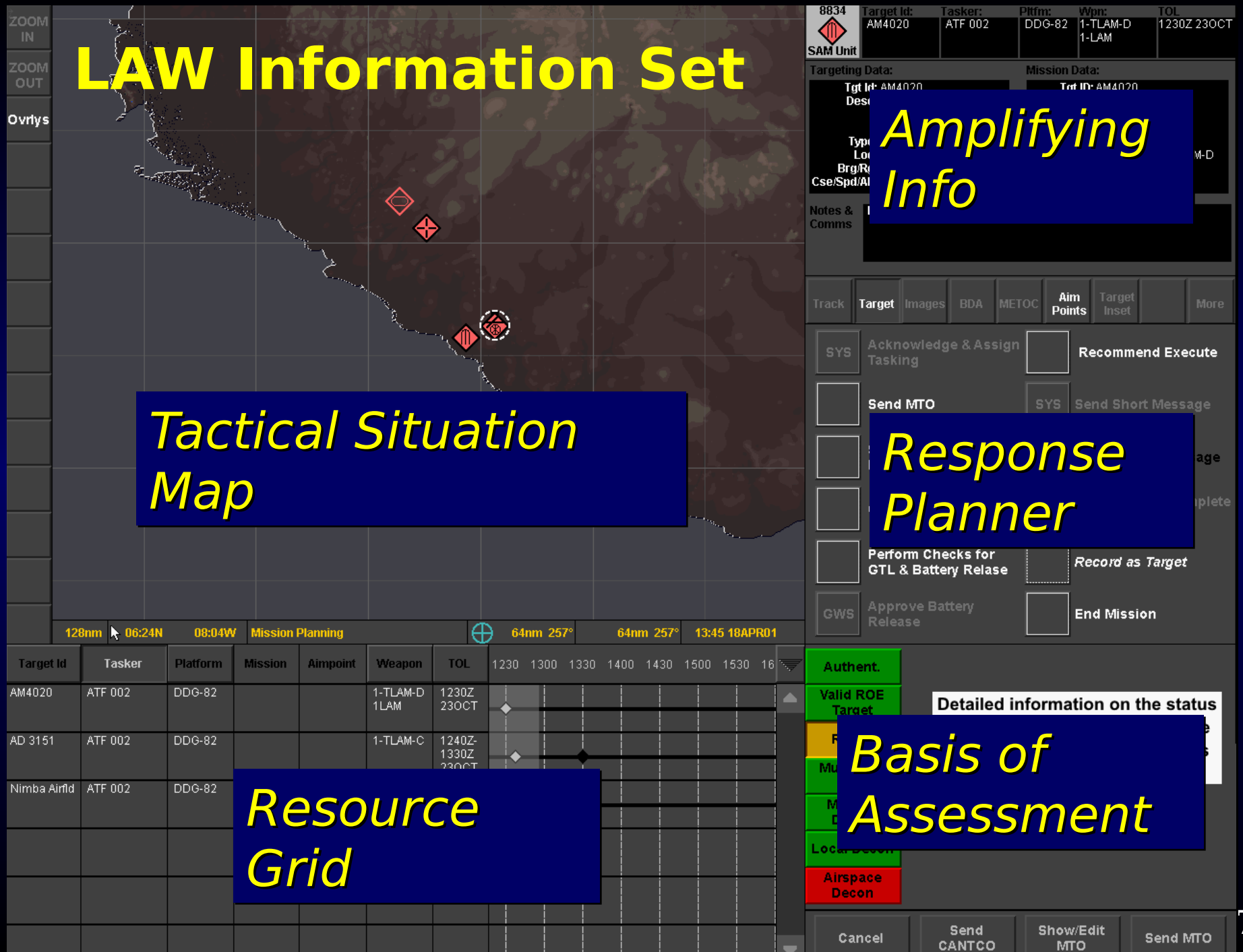
Task Manager Task Queue



Communications



Systems Status


LAW Information Set
Tactical Situation Map
Amplifying Info
Response Planner
Resource Grid
Basis of Assessment
ZOOM IN
ZOOM OUT
Ovrlys
8834
SAM Unit
Target Id:
AM4020
Tasker:
ATF 002
Pltfm:
DDG-82
Wpn:
1-TLAM-D
1-LAM
TOL
1230Z 23OCT
Targeting Data:
Mission Data:
Notes & Comms
Track
Target
Images
BDA
METOC
Aim Points
Target Inset
More
SYS
Acknowledge & Assign Tasking
Recommend Execute
Send MTO
SYS
Send Short Message
Perform Checks for GTL & Battery Release
Record as Target
GWS
Approve Battery Release
End Mission
128nm
06:24N
08:04W
Mission Planning
64nm 257°
64nm 257°
13:45 18APR01
Target Id
Tasker
Platform
Mission
Aimpoint
Weapon
TOL
1230 1300 1330 1400 1430 1500 1530 16
AM4020
ATF 002
DDG-82
1-TLAM-D 1LAM
1230Z 23OCT
AD 3151
ATF 002
DDG-82
1-TLAM-C
1240Z-1330Z
Nimba Airfld
ATF 002
DDG-82
Authent.
Valid ROE Target
Airspace Decon
Detailed information on the status
Cancel
Send CANTCO
Show/Edit MTO
Send MTO

ADW Information Set
Amplifying Info
Tactical Situation Map
Response Planner
Priority Tracks Awaiting Task Completion
Draft Task Product Summary
Basis of Assessment

MMWS Human Performance Testing

Individual Usability Testing

- Speed
- Accuracy
- Situation Awareness

- Workload
- Comfort/Ergonomics
- Learnability

Team Warfighter Testing

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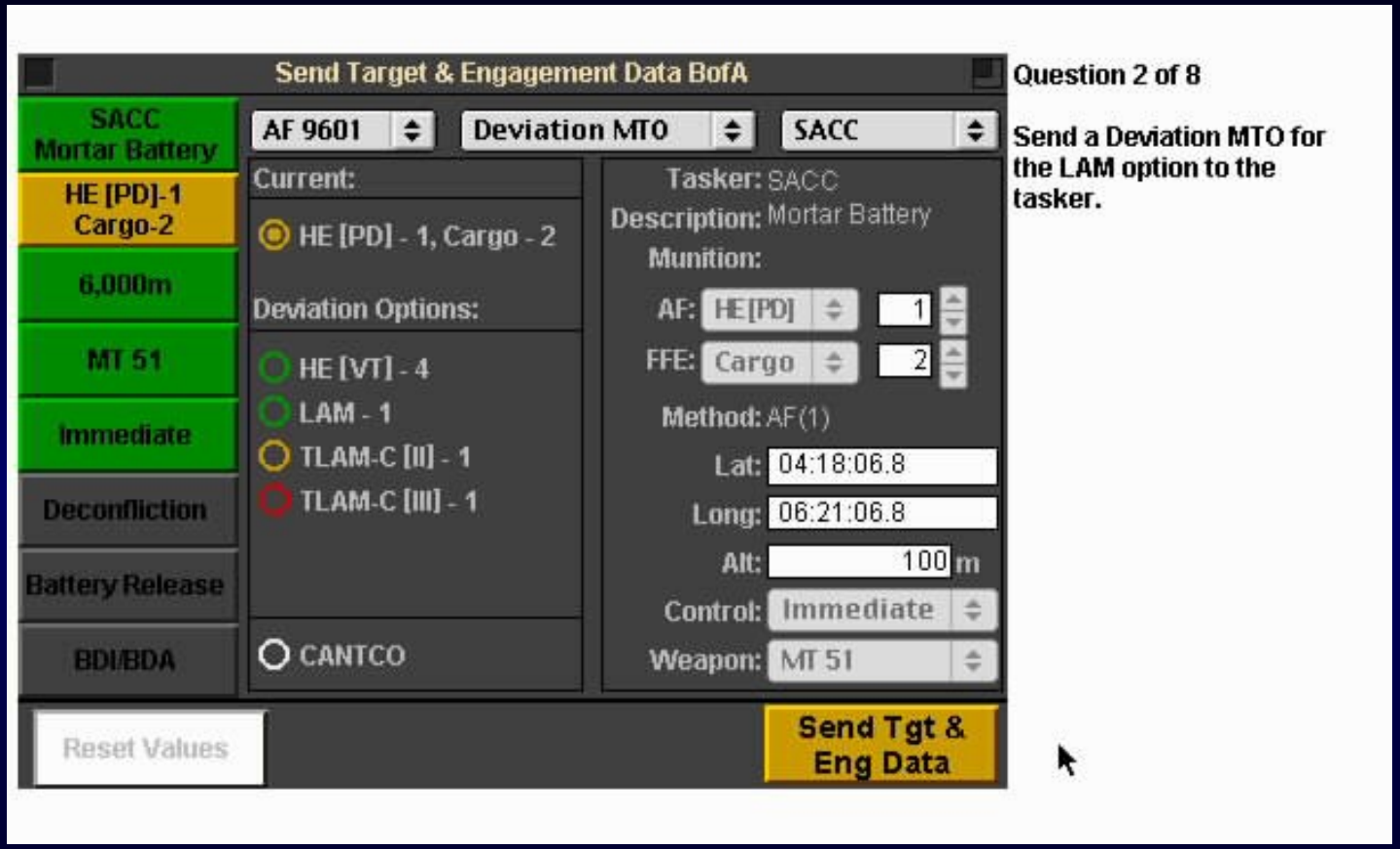
On-Line Usability Testing



Capability to capture fleet input from any internet access point globally on new design evaluations.

MMWS TEAM PERFORMANCE TEST
BATTLEGROUP AIR-DEFENSE WARFARE

Team Performance: ADW

Tactical and Communications ADW Team Tasks

-Communicate Results to Battlegroup
-Communicate Results to Allies
-Coordinate Battlegroup Defensive Counter Air
-REDCROWN - screen aircraft in battlegroup

Identify & Monitor

Query & Warn

Illuminate & Cover

Missile or Gun Engage

Chaff & Jam

Close-in-Weapons Defense

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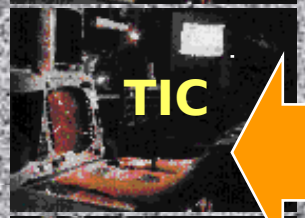
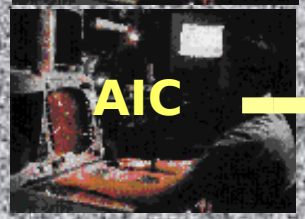
Team Performance

Aegis ADW Team





MMWS ADW Team

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AEGIS Combat System

CG47 Ticonderoga Class

DDG51 Arleigh Burke Class

AEGIS Combat System (TIC Workspace)

Team Performance: ADW

Today - struggle for Level 1 SA

Trigger - human observation, limited automation (doctrine),

Orient - search, aggregation across disparate sources.

Decide - no decision support systems. Raw data presented.

Produce- products are manually produced by hand or verbally. Some engage options.

Deliver- Many tasks manual.

Confirm - often poor feedback. No tracking of tasks.

Transition - No user help.

MMWS - Level 2 and Level 3

Trigger - automation assists in all major mission tasks.

Orient - bring info to warfighter in concise formats.

Decide - provide evidence & explanation.

Produce- provide for review of draft products.

Deliver- simplify delivery and execution.

Confirm - thorough feedback for current, past and future tasks planned.

Transition - orient toward critical activities needing attention.

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TEAM TESTING

OFFICE OF NAVAL RESEARCH

Task Outcomes
Operator Detect
Track Verbal Reports
Q&W
DCA VID
Cover
Illuminate
AIC Taskwork

Example Task Outcomes:

Cover
(with Standard Missile)

- **Cover action - personality-driven tactical decision.**
- **MMWS-1 team actions suggest a different underlying SA, which might be inferred as tactically better.**

Cover not needed

Lower

Tactical Significance

Higher

ETN	Aegis	MMWS One	MMWS Two
70 (Surv)	1 of 8	0 of 6	track anomaly
101 (CNN)	2 of 8	0 of 6	0 of 2
200 (Low-E)	2 of 6	4 of 6	1 of 2
132 (Shooter)	1 of 8	5 of 6	2 of 2

Cover may be critical

Task Outcomes
Operator Detect
Track Verbal
Reports
Q&W
DCA VID
Cover
Illuminate
AIC Taskwork

Example Task Outcomes:

Illumination
(with Missile FCR)

- **ROE change authorizing illumination issued during higher stress period.**
- **Illumination action - personality-driven tactical decision.**
- **MMWS1 suggest a different and more consistent underlying SA, which might be inferred as tactically better.**

Illumination not needed

ETN	Aegis	MMWS One	MMWS Two
70 (Surv)	5 of 8	0 of 6	track anomaly
101 (CNN)	3 of 8	0 of 6	0 of 2
200 (Low-E)	3 of 6	4 of 6	2 of 2
132 (Shooter)	2 of 8	4 of 6	1 of 2

Illumination may be critical

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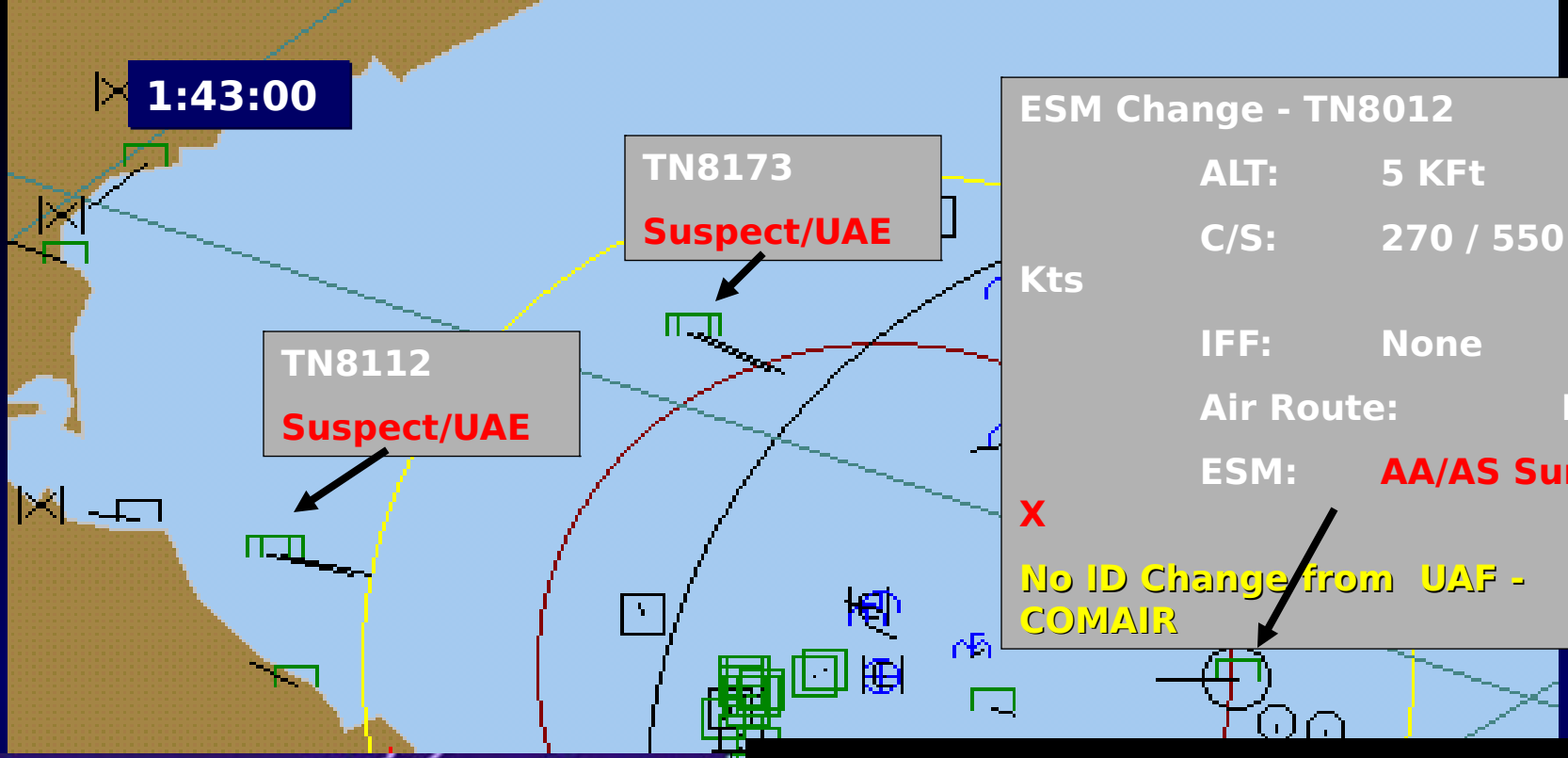
Critical Track Result

	KINEMATICS	TRK ESM	QUERY/WARN	MSL ESM	ENGAGE
Crew 1	No	Yes	No	No	No
Crew 2	No	No	No	No	Yes
Crew 3	Partial	No	No	No	Yes
Crew 4	Partial	Yes	Ordered	Yes	Yes
Crew 5	No	No	No	Yes	Tried to
Crew 6	Yes	Yes	Yes	Yes	Yes
Crew 7	No	Yes	Yes	Yes	Yes
Crew 8	No	Yes	No	Yes	Would have
Crew 9	No	Late	No	Yes	Would have

8 of 9 Aegis teams had no response to kinematic change.

ALL MMWS teams responded in a timely manner and were ready for threat before hostile missile launch.

Lack of AEGIS early response leads to last second

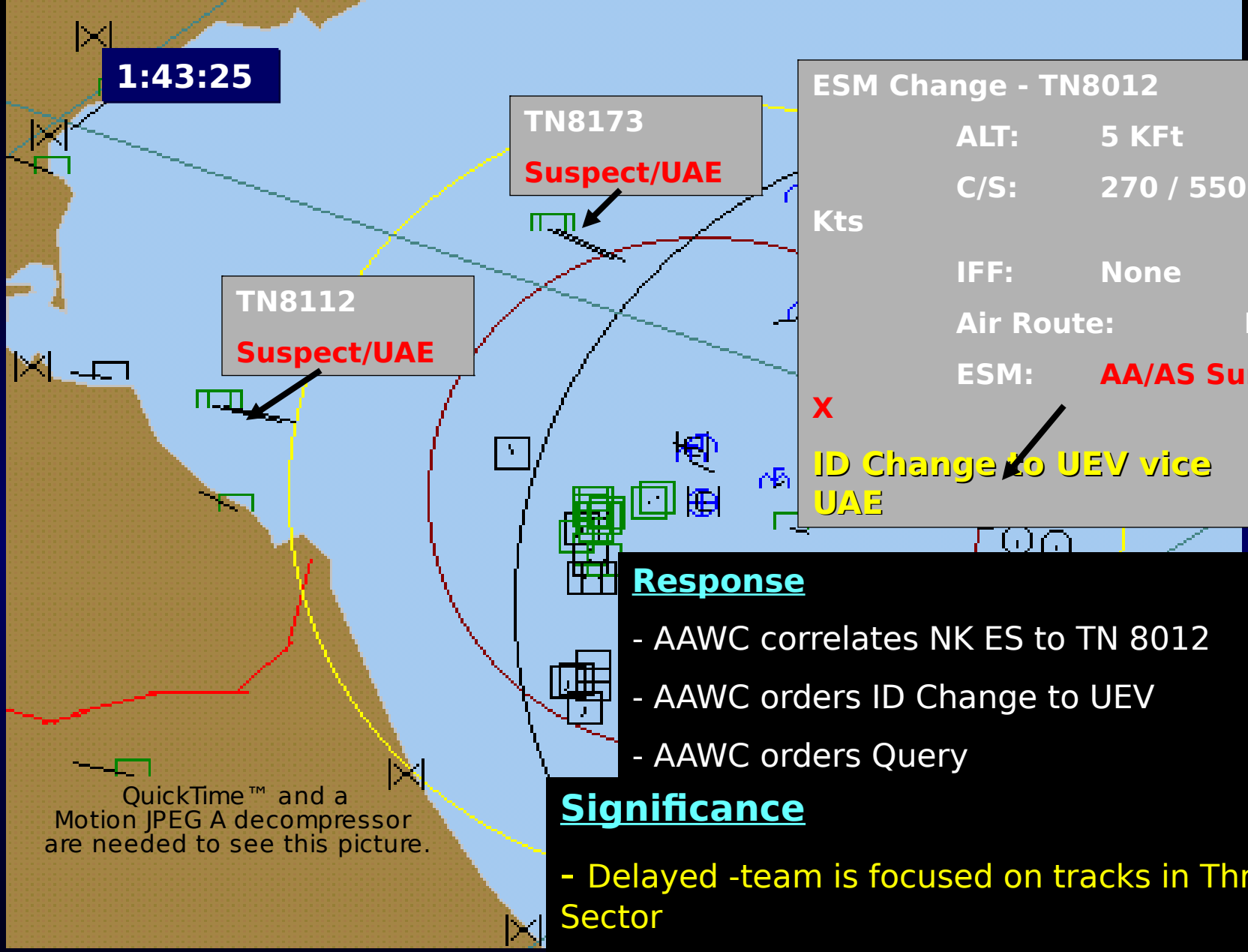


Response

- TAO requests EW repeat ES report to East

Significance

- ‘disbelief’ of Suspect ES to East
- Delayed because team is focused on tracks in Threat Sector
- Team did not modify ID to UAE
- Track meets criteria for Warning
- Update voice report to BW required



Response

- AAWC correlates NK ES to TN 8012
- AAWC orders ID Change to UEV
- AAWC orders Query

Significance

- Delayed -team is focused on tracks in Threat Sector
- Team did not modify ID to UAE
- Track meets criteria for Warning

Team ADW Performance

Air Warfare Coordinator

Example

TN132
Response

Situation Awareness

Confidenc

eaction

s

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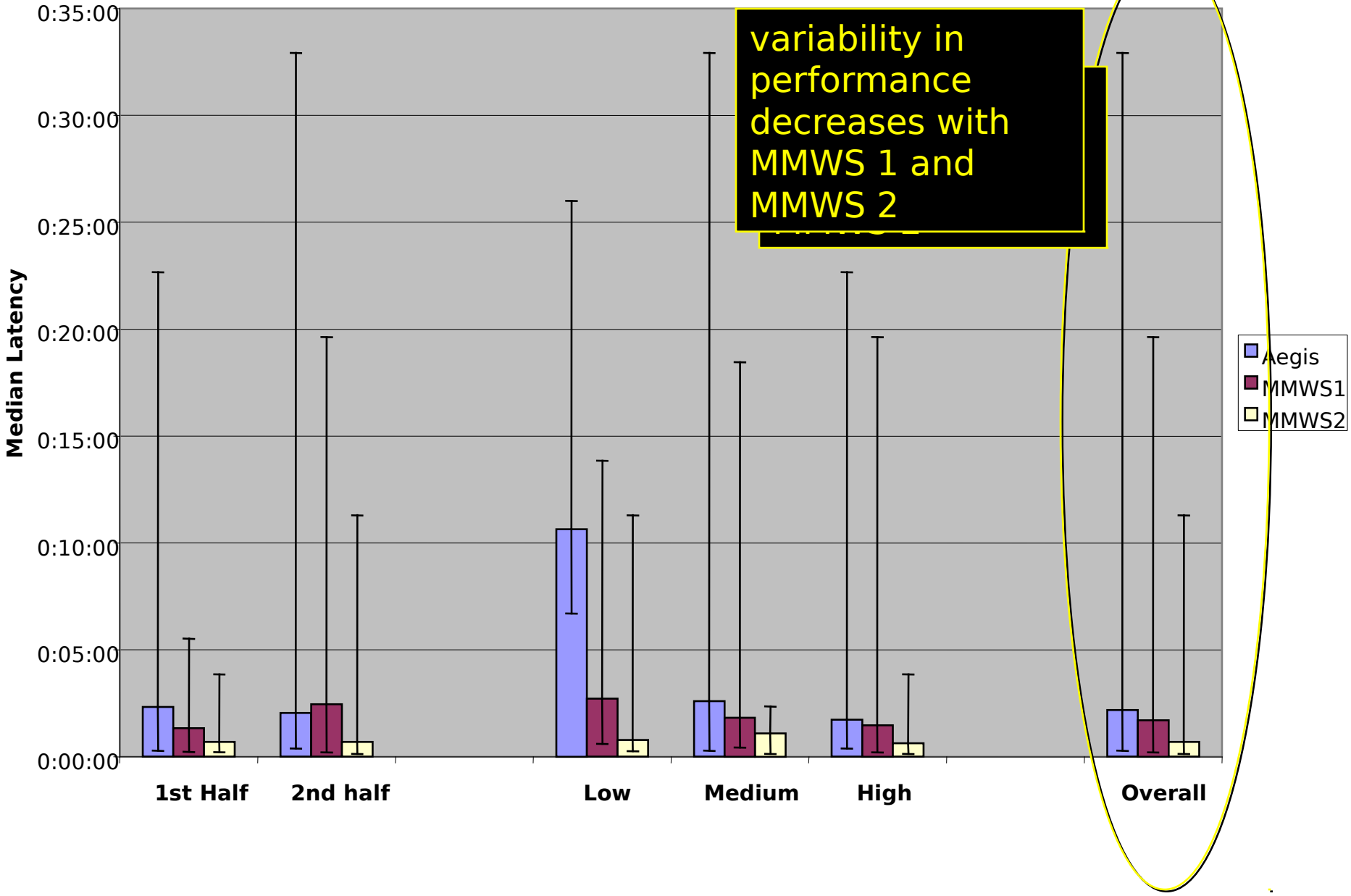
New Track Verbal Report



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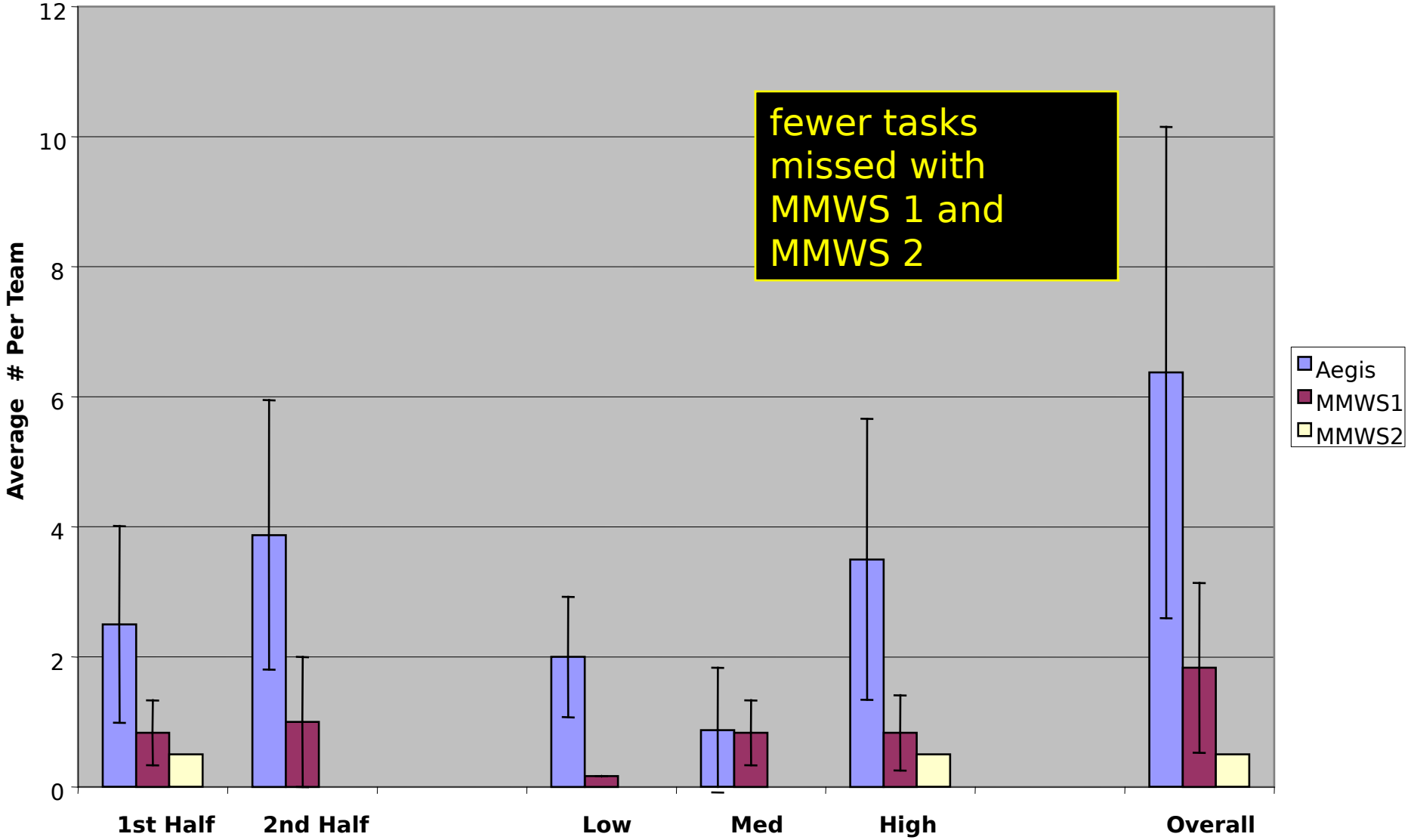
Missed New Track Verbal Reports



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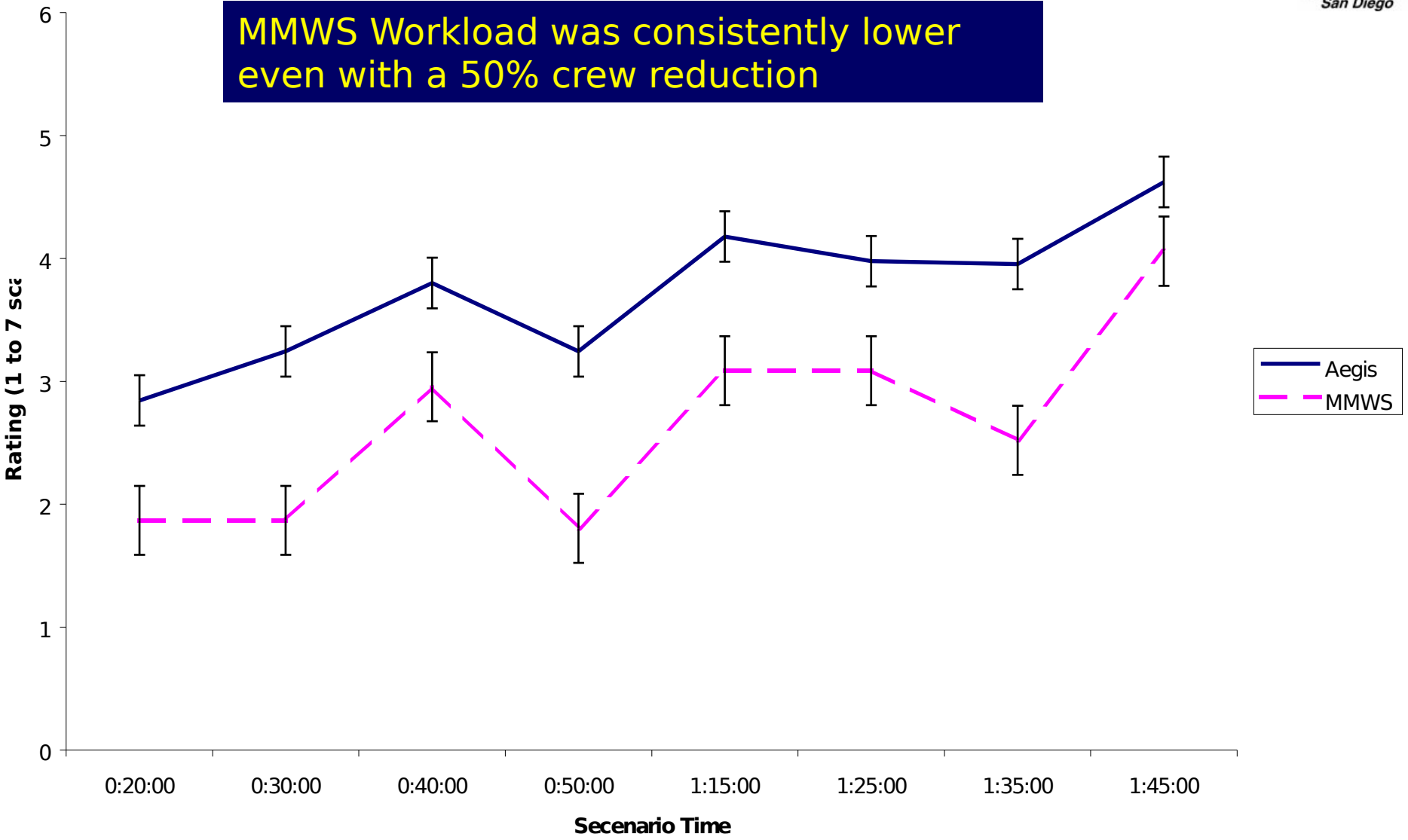
SME Ratings of Watchstander Workload

MMWS Workload was consistently lower even with a 50% crew reduction



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Team ADW Test Summary

AEGIS-MMWS Comparison Testing

- 2-hr Air Defense Warfare scenario
- 8 intact Aegis teams (8 operators)
- 8 MMWS teams (4 operators)

MMWS teams of 4 operators had:

- equal or better performance
- lower variance (timeliness of actions)
- equal or lower workload
- equal or better SA

in 8 hours or less of training!!